ERM-INV Model Solutions
Fall 2022

1.

Learning Objectives:

1. The candidate will understand the ERM framework and process and be able to apply them to organizations.

4. The candidate will understand how the risks faced by an entity can be quantified and the use of metrics to measure risk.

5. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

6. The candidate will understand the concept of economic capital, risk measures in capital assessment and techniques to allocate the cost of risks within business units.

Learning Outcomes:

(1a) Recommend an appropriate framework for an organization's enterprise risk management and an acceptable governance structure.

(1c) Demonstrate how to articulate an organization's risk appetite, desired risk profile, quantified risk tolerances, risk philosophy and risk objectives.

(4b) Analyze quantitative financial and non-financial data using appropriate statistical methods to assist in quantifying risk.

(5e) Determine an appropriate choice of mitigation strategy for a given situation, which balances benefits with inherent costs (including exposure to moral hazard, credit, basis and other risks).

(5i) Choose appropriate techniques to measure, model and manage various financial and non-financial risks faced by an organization.

(6b) Apply risk measures and demonstrate how to use them in value and capital assessment

(6d) Demonstrate the ability to develop a capital model for a hypothetical organization

1. Continued

Sources:
ERM-110-12: Derivatives: Practice and Principles, Recommendations 9-24 and Section III

ERM-702-12: IAA Note on ERM for Capital and Solvency Purposes in the Insurance Industry, Pages 9–3

ERM-119-14: Aggregation of risks and Allocation of Capital (Sections 4-7 Excluding 6.3)

Commentary on Question:
This question tests the candidates' ability to apply knowledge and concepts related derivatives, economic capital, modeling approaches and efficient capital allocation. The candidate is required to use the case study as well as other perspectives introduced in the question stem to evaluate strategic decisions. The final recommendation required candidates to revisit all parts of the question to provide a level of justification similar to what would be required in a real business setting. Candidates generally scored well on parts (b) and (c). Scores on parts (a) and (d) however, were generally low due to failure to apply the case study and additional information provided in the question.

Solution:
(a)   SLIC has recently engaged more heavily in the use of interest rate swaps to mitigate interest rate risk. SLIC currently uses Lyon's approach of applying a factor to Corporate assets to account for credit risk in the EC framework.

Annabelle, your actuarial student, asserts the exposure to interest rate swap counterparties constitutes additional credit risk and as a result, SLIC's credit risk profile is now materially different than that of Lyon's Corporate assets. She plans to show that continuing with a factor approach may no longer be appropriate for SLIC.

You are given the following information:

- Annabelle suggests that assessing the counterparty credit risk for interest rate swaps will add complexity.
- Annabelle will draft a communication to alert senior management of the emerging counterparty risk, but she admits the risk's relevance is not obvious until she completes a materiality study.
- Annabelle acknowledges that it will be difficult to explain the change in credit risk to internal stakeholders, since swaps are new to both SLIC and Lyon. However, the associated credit risk is well-documented industry-wide and best practices exist for assessing the risk.

1. Continued

Assess the appropriateness of continuing with the factor approach to determine credit risk for SLIC based on Annabelle's suggested approach. Justify your answer.

Commentary on Question:
Candidates generally scored low on this question and few received full credit. Reponses that scored low failed to use the information provided in the question to assess the appropriateness of the factor approach. Several candidates also provided brief responses that did not align with the number of points possible for the question. Responses that recommended maintaining the factor approach could receive full credit as long as sufficient justification was provided.

The credit risk for a derivatives transaction fluctuates over time and to appropriately assess it, one needs to determine both current exposure and potential exposure. Current exposure is straightforward since it simply asks for the current market value of a derivative. Potential exposure is more difficult since it calls for an assessment of what the replacement cost of the derivatives transaction would be in the future, if the underlying variables that determine the value of the contract move adversely. The potential exposure in 1 year is needed to assess economic capital so Annabelle is correct that there is added complexity to SLIC's credit risk profile and it will be difficult to reasonably assess using a factor approach.

Annabelle has categorized this as an emerging risk. An emerging risk is a developing or already known risk which is subject to uncertainty and ambiguity and is therefore difficult to quantify using traditional risk assessment techniques. Although the risk is new and not well understood by SLIC, this is not an emerging risk since it is well understood in the industry and best practices exist for assessing. The existing best practices can be leveraged to re-evaluate SLIC's credit risk and compare to results using the factor approach. This will certainly be helpful in the materiality assessment. Also, best practices can be used to overcome the challenge of explaining the changes in credit risk to internal stakeholders, making stakeholders more comfortable with any new methodology.

Given that the factor approach cannot reasonably capture the complexity of the credit risk related to swaps and the fact that there are existing methods available to assess and explain the changes, it is not appropriate to continue with the factor approach.

1.   Continued

(b)   You and Annabelle decide to recommend that SLIC move to a more sophisticated approach to calculating EC for interest rate swap credit risk. Annabelle proposes the following:

1. Use a Monte Carlo simulation combined with an appropriate interest rate model to generate interest rates in one year.

2. From the resulting distribution of projected interest rates, determine the VaR(85) of the replacement value of each swap transaction. The replacement value for each swap is the credit exposure.

3. For counterparties with multiple swaps, assume netting applies and is enforceable. Then the potential exposure for that counterparty is the gross loss; that is, the sum of all positive exposures only.

4. The maximum potential exposure is then simply the sum of all individual counterparty exposures.

Critique each of Annabelle's proposed steps.

Commentary on Question:
Candidates scored well on this question. A thorough critique of each step was required for full credit. Justification related back to the information provided in the question was required to receive full credit.

Monte Carlo simulation is a generally accepted approach to interest rate modeling since it is flexible and can generate thousands of scenarios reflecting different interest rate movements. It is therefore a good choice for measuring VaR. It also has the capability to reflect market dynamics and interactions between risks. It will be key, however, to choose an interest rate model that can generate sufficiently adverse movements to determine a meaningful VaR measure. SLIC will require internal experience and expertise on Monte Carlo modeling and interest rate models, which may be a challenge depending on current resources. The costs should be weighed against the benefits before proceeding with this approach.

1. Continued

VaR is appropriate for measuring and communicating risk through the lens of economic capital since most people are familiar with it and it provides a straightforward measure of the capital needed to protect to a desired level of confidence. For economic capital, however, a measure that is sufficiently extreme that it is unlikely to be exceeded should be chosen. Calculating the replacement value under various interest rate scenarios is reasonable, but they should consider a confidence level between the 95th and 99th percentiles to be consistent with subsidiaries. A lot can happen beyond the 85th percentile in the tail. Also, other subsidiary economic capital models use confidence levels much further out in the tail, indicating that their risk appetite is lower. As a supplement, Annabelle can look beyond the VaR level to gather additional information about the risk not covered by economic capital and educate everyone on the potential downsides to using an incoherent risk measure such as VaR.

In calculating the current replacement costs for a portfolio of transactions with a counterparty, it is important to know whether netting applies and is enforceable. Netting should not be assumed unless master agreements can be checked, as the risk will be understated for each counterparty where netting is not established. Also, if netting applies, the potential exposure should be the net loss or sum of both positive and negative exposures. The gross loss should be considered where netting does not apply.

The suggested calculation of Maximum Potential Exposure is flawed. For large, diversified derivatives portfolios, worst-case exposure becomes a less useful measure since it is highly unlikely that all worst-case outcomes will occur simultaneously. Correlation should be assessed and some level of diversification should be reflected.

With the corrections stated above, all of the proposed steps will introduce more rigor to SLIC's assessment of credit risk and should make both SLIC and Lyon more confident that they are improving their ability to accurately measure and manage credit risk.

1. Continued

(c) Senior management shifts focus to the enterprise assessment of EC, as described in Lyon's recent ORSA report.

Refer to sections 2.11 and 2.12 of the Case Study.

(i) Discuss an advantage and a disadvantage of Lyon's approach to calculating required EC.

(ii) Annabelle suggests that it is reasonable to assume complete independence between all of Lyon's subsidiaries, including Lyon Corporate, under normal business and economic conditions. She proceeds with the independence assumption and calculates a combined required EC of $2,048,357,000 reflecting the diversification benefit of $1,288,269,000.

Critique Annabelle's assumption.

(iii) Marcus, your supervisor, states it is a mistake to use Annabelle's correlation assumption in a <u>stressed</u> business and economic environment.

Explain your supervisor's statement.

(iv) Propose two unique modeling solutions that could address the correlation issue. Justify your answer.

Commentary on Question:
Many candidates were able to provide responses for part (c) that received close to full credit. Only partial credit was awarded for those responses without justification. For sub-parts (i) and (iv), any reasonable response was awarded full credit as long as the candidate could justify the response.

(i) Lyon's approach to calculating required economic capital is to simply sum the economic capital from each of its subsidiaries. One advantage of this approach is that it provides a conservative view of economic capital since it effectively assumes 100% correlation between each of the subsidiaries. One disadvantage to this conservative measure, however, is that economic capital is overstated. The objective is to set economic capital efficiently so capital can be deployed in a way that maximizes returns for Lyon. Setting EC too conservatively goes against the principal of maximizing returns.

1. Continued

    (ii)   The assumption of complete independence effectively assumes zero correlation between each of Lyon's subsidiaries, but this should be assessed for reasonableness based on the risk sources. Helios, SLIC and AHA, for example, are all life and health companies so assuming complete independence between all three would likely be inappropriate. Also, she should not be assessing correlation during normal business and economic conditions since economic capital is meant to reflect tail risks. Given that complete independence is not reasonable, the calculation of $2,048,357,000 is reflecting too much diversification benefit and understating the economic capital Lyon should be holding.

    (iii)   Annabelle is assuming zero correlation between the risk sources during normal business and economic conditions. Assuming the same level of correlation is not acceptable during extreme events. Economic capital is calculated to provide protection during extreme events so assessment of correlation in this part of the loss distribution, where risks often exhibit increased correlation, is of greatest interest. For example, systemic risks such as market downturns are likely to impact each subsidiary in some way, even if they were independent during normal business and economic conditions. Failing to reflect some level of increased positive correlation in extreme events will understate required economic capital.

    (iv)   Lyon should pursue modeling solutions that can reflect increased correlation in the tail.

          One suggestion is to use copulas to solve this problem. A copula function can be defined and specified such that the interaction between correlated risks differs at different parts of the combined distribution. A T-copula, for example, could achieve some level of increased tail risk.

          Another suggestion for addressing increased tail risk is using multi-variate methods as they allow interaction between risk factors directly in the aggregated risk impact. This can work if Lyon is able to assess the change in correlation from normal to stressed conditions.

          Annabelle will need to understand that any method used to reflect increased tail correlation will reduce the diversification benefit she previously calculated.

1.   Continued

(d)   You have completed additional analyses and determine the following:

- The changes for the enterprise EC would result in approximately 50% of the diversification effect shown in (c)(ii).
- The changes to the calculation of credit risk could further reduce Lyon's EC by approximately 5% of the diversification effect shown in (c)(ii).

Recommend if Lyon should move forward with each of the changes, based on your answers to (a) through (c) and the additional analyses above. Justify your response.

Commentary on Question:
Most responses provided for part (d) were not sufficient for full credit. Responses were generally brief and did not reflect the level of detail implied by the maximum number of points available for the question. Also, many responses failed to use answers from previous parts of the question to justify the recommendation. Any recommendation could have received full credit with proper justification.

Assuming the recent assessments of diversification have addressed all issues stated prior, Lyon should move forward with the proposed changes to both their credit EC and enterprise EC. Lyon is a large company with a complicated structure, making their economic capital calculations and their credit risk profile complex. A more sophisticated approach to calculating EC is therefore warranted and they've also prioritized improving EC calculations this year.

From the enterprise perspective, diversification should be reflected for such a large, sophisticated company. The diversification effect is now approximately $644M (50% of $1.288B). The reduction from $1.288B reflects that Annabelle addressed Marcus' concerns and was able to incorporate increased correlation in the tail. Although there will be costs involved with monitoring and assessing changes in correlation, Lyon can now confidently move forward and assess where the newly accessible capital of $644M can be used to maximize returns such as growing the company organically, or new acquisitions. Also, now that the tail correlation has been appropriately assessed, the change is straightforward to implement since it is purely formulaic. Lastly, there will be no burden on the subsidiaries since they will not need to make changes to their EC calculations.

1. **Continued**

From the credit risk perspective, again Lyon is a large, complex company and it has been established that their credit risk profile has changed materially, warranting a more detailed credit risk calculation. The required modeling to assess credit risk under the new methodology is much more complex and will require additional resources compared to the enterprise change. It was also noted that the changes will be difficult to explain to stakeholders. They do benefit however from the release of another $64M (5% of $1.288B) of capital. $64M is small compared to $644M from the enterprise change, but it's unlikely that the additional resources required will cost more than $64M. It is therefore worthwhile to invest the time and resources necessary for explaining the changes and making all stakeholders comfortable. Since the change in methodology is not required, i.e. the decision is internally driven, they can also take time to slowly phase the changes in to lessen the strain on resources.

2. Learning Objectives:

2. The candidate will understand the types of risks faced by an entity and be able to identify and analyze these risks.

3. The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.

4. The candidate will understand how the risks faced by an entity can be quantified and the use of metrics to measure risk.

5. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

6. The candidate will understand the concept of economic capital, risk measures in capital assessment and techniques to allocate the cost of risks within business units.

Learning Outcomes:

(2c) Identify and analyze specific risks faced by an organization, including but not limited to: financial, environmental, operational, legal, reputational and strategic risks.

(3a) Demonstrate how each of the financial and non-financial risks faced by an organization can be amenable to quantitative analysis.

(3g) Evaluate and select appropriate models to handle diverse risks, including models that use a stochastic approach.

(4b) Analyze quantitative financial and non-financial data using appropriate statistical methods to assist in quantifying risk.

(5d) Demonstrate how derivatives, synthetic securities, and financial contracting may be used to reduce risk within a static or dynamic hedging program.

(5f) Demonstrate the use of tools and techniques for identifying and managing credit and counterparty risk.

(6b) Apply risk measures and demonstrate how to use them in value and capital assessment

Sources:

Value-at- Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion Ch. 12: Monte Carlo Methods

ERM-106-12: Economic Capital-Practical Considerations, Milliman

2. Continued

ERM-110-12: Derivatives: Practice and Principles, Recommendations 9-24 & Section III

Financial Enterprise Risk Management, Sweeting, Paul, 2nd Edition, 2017
Ch. 8: Risk Identification

Commentary on Question:
This question is intended to test Monte Carlo simulation, economic capital calculations, and risk identification for a variable annuity product with guaranteed minimum benefits and an associated dynamic hedging program.

Overall, candidates did moderately well on the written answer portions but struggled significantly with the Excel calculations.

The stock price model given in the question stem gave the stock price at time T as a function of the stock price at time 0. Some candidates correctly noted in their critique that this is a drawback of the proposed EC model, as a random walk would typically base S(T) on the prior stock price S(T-1). Although candidates were expected to apply the formula in the question stem in the Excel model, it was decided that full credit for the S(T) calculation would also be given to correct application of a revised formula which based S(T) on S(T-1).

Most candidates were able to correctly calculate the management fees, but few candidates took the necessary step of reducing the account value by the management fee each year. Most candidates also showed a lack of understanding of how payoffs of GMDB and GMAB benefits are calculated.

There was some difficulty amongst candidates in correctly understanding the impact of dynamic hedging, but most performed better with risk assessment and identification.

Solution:
(a)   EFG's CRO would like to integrate the VA product into the company Economic Capital (EC) model. You are given the following assumptions:

- The annual mortality rate is assumed to be constant at 0.001
- Renewals, withdrawals, and rollovers are ignored
- The discount rate is 3.00%.

Equity returns are modeled using the distribution described below.

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2. Continued

- $S(T) = S(0)e^{\left(\mu - \frac{\sigma^2}{2}\right)T + \sigma\epsilon\sqrt{T}}$, where
- S(0) = 1.0
- μ = 3.00%
- σ = 0.3, and
- ε is a random variable from a N(0,1) distribution.

The EC framework will be based on 100 scenarios of equity returns for the next 10 years. The EC requirement is set as CTE(95) - CTE(0) based on the distribution of losses.

95 total simulations have already been run, and the resulting liability calculations are shown on the tab 'Q2(a)(rank)' in the accompanying Excel workbook. Pseudo-random simulated values from the U(0,1) distribution for the final five scenarios are also available on the tab 'Q2(a)(cash flow)'.

(i) Describe the process of simulating stock price paths using Monte Carlo methods.

(ii) Calculate the required EC for the VA risk. Show your work.

(iii) Critique EFG's approach for modeling EC for VA risk.

Commentary on Question:
Subpart (i)
Many candidates received close to full credit on this question, with those who received less failing to get into sufficient detail about the Monte Carlo simulation process. However, almost all candidates received at least some credit for their responses.

Subpart (ii)
Overall, candidates struggled with the Excel calculations, with very few candidates receiving close to full credit. Most candidates correctly executed the simpler calculations, such as the normal inverse, account value, persistency, management charges, and the discounting factor. However, very few candidates correctly understood how to calculate the guarantee cashflows, or recognized that they were outflows from the perspective of EFG. Several candidates also struggled with the application of the stock price path formula given in the question stem. Even with errors in the preceding steps, the majority of candidates correctly calculated the CTE and EC measures.

2. **Continued**

Subpart (iii)
Candidates generally performed well on this question, with many receiving full credit. Most candidates recognized that there was not a sufficient number of simulations, and that the mortality and policyholder withdrawal assumptions were too simplistic or missing altogether. Though none are listed in the model solution below, credit was also given for valid positive critiques with justification that related to EFG and the EC model in question.

(i) Assume that stock prices follow a given model, such as the one for S(T) given above, which has a random error term that follows the Normal (0,1) distribution. First, simulate a set of randomly generated values from the uniform (0,1) distribution. Transform the simulated variables using the inverse cumulative N (0,1) probability distribution. Using the selected model and randomly simulated error terms, calculate the stock price into the future. Repeat several times.

(ii) Refer to Excel for calculation solutions.

(iii) EFG's EC model has several shortcomings that are mostly due to oversimplification.

The model does not reflect the potential impact of policyholder behavior such as lapse or withdrawal. Given the reduction in surrender charges after three years, policyholders may exhibit dynamic behavior that is not accounted for.

Additionally, mortality is assumed to be a constant rate that does not consider policyholder age or vary by time. Discount rates are similarly static.

Lastly, 100 simulations are too few to produce a reliable result. EFG should add more simulations to the EC calculation.

(b) To manage risks associated with VA guarantees, EFG is planning to implement a dynamic hedging program.

(i) Describe the risks associated with implementing and maintaining dynamic hedging as it relates to the new VA product.

(ii) Explain how dynamic hedging could be reflected in EFG's EC framework.

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2. Continued

Commentary on Question:
Subpart (i)
Candidates generally performed well on this part of the question, with the majority earning at least half of the points available. Many candidates tended to focus on operational risk, for which credit was given if it was tied back to the scenario in this question, but did not put enough emphasis on the market and financial risks associated with dynamic hedging.

Subpart (ii)
Candidates tended to struggle with this explanation, with many responses being too vague or simplistic. Those who received more credit were able to correctly explain the impact of hedging on the economic capital calculations that were presented earlier in the question.

(i)   Dynamic hedging programs introduces multiple associated risks.

Basis risk – the potential for mismatches in the hedged position given that the hedge is not perfectly correlated with the underlying fund.

Higher than expected transaction costs, given the potential for frequent rebalancing of the hedge portfolio.

If the hedge requires investment in a position with a thin market, EFG could experience market liquidity risk resulting in increased hedging costs or an inability to purchase the hedge at all.

Given that EFG is new to the VA market and dynamic hedging in general, operational inexperience in these areas could lead to mistakes and further losses.

(ii)   To incorporate dynamic hedging, EFG should model the hedge as part of the existing EC framework. To do so, assets representing the hedge need to be modeled. Cashflows resulting from these hedging assets should serve to offset a portion of the expected guarantee cashflows. The model should incorporate appropriate transaction costs reflecting the rebalancing of the hedge assets. Adjusted liability cashflows accounting for these impacts of the hedge should be used to calculate the new capital requirement.

(c)   Within two years of the successful product launch, EFG Life grew its assets under management by 500%. Due to this growth, EFG doubled its workforce and implemented a new hedging platform and administrative system to manage the VA business but did not have enough time to properly train the new employees.

2. **Continued**

EFG had previously identified the following key risks arising from the traditional life insurance business:

- Mortality
- Interest rate
- Credit
- Liquidity

(i) Evaluate how the success of the new VA product launch should be reflected in the assessment of each of these risks.

(ii) Recommend two *key* additional risks that EFG should consider when assessing the newly launched VA block. Justify your recommendation.

Commentary on Question:
Subpart (i)
Candidates performed moderately well here, with those who received credit doing a better job of specifically assessing the impact on each of the risks. Some candidates were too general in that they stated EFG should simply assess/evaluate the risks, but didn't elaborate on potential impacts. There were several different interpretations of exactly what the question was asking, with some candidates seeming thrown off by the word "success" in the question. Credit was given for alternative interpretations of the question as long as they made valid points relating to how the new VA product would interact with the listed risks above.

Subpart (ii)
Candidates did very well in identifying additional risks. The most common pitfall was recommending a risk but not justifying how it related to EFG or the VA product launch.

(i) Mortality risk: though annuities typically have offsetting mortality/longevity risk profiles with traditional life insurance, the existence of the GMDB in this VA will serve to increase mortality risk for EFG, as they are liable for 100% of the initial investment upon the death of the policyholder.

Interest rate risk: there is minimal direct impact from interest rates as the VA accounts are invested in various equity mutual funds. Low interest rates will made the GMDB and GMAB benefits more expensive to hedge, however.

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2. **Continued**

Credit risk: as the VA block grows and EFG increases its hedge positions as a result, credit risk will likely increase as the number of counterparties and exposures grows.

Liquidity risk: given the reduction in surrender charges in future years, liquidity risk will be a concern for EFG as policyholders are more likely to increase withdrawals under stressed economic conditions.

(ii)   Equity risk: poor performance of the equity markets could trigger increased GMDB and GMAB payouts.

Operational risk: due to the inadequate training for employees, operational risk is significantly increased and could result in business disruption or process failures.

3. **Learning Objectives:**
1. The candidate will understand the ERM framework and process and be able to apply them to organizations.

2. The candidate will understand the types of risks faced by an entity and be able to identify and analyze these risks.

5. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

Learning Outcomes:
(1d) Assess the overall risk exposure arising from an organization's current and emerging risks.

(2c) Identify and analyze specific risks faced by an organization, including but not limited to: financial, environmental, operational, legal, reputational and strategic risks.

(5h) Demonstrate possible risk management strategies for non-financial risks.

Sources:
ERM-133-19: Emerging Risks and Enterprise Risk Management (pp. 2-6)

Financial Enterprise Risk Management, Sweeting, 2017, Ch. 8 Risk Identification

Financial Enterprise Risk Management, Sweeting, 2017 Ch. 16 Responses to Risk

ERM-145-21: IAA Paper: Importance of Climate-Related Risks for Actuaries (Pages 2-14)

ERM-137-20: ORSA and the Regulator by AAA

Commentary on Question:
The question tests candidates' ability to identify, assess, and mitigate emerging risks, and climate risk in particular. The question also tests candidates' ability to discuss emerging risks in the context of an ORSA report.

Solution:
(a) Rank the appropriateness of the following risk identification techniques for emerging risks. Justify your ranking.

- Individual risk interviews of Lyon's senior management
- Brainstorming among Lyon's senior management as a group
- Case studies of other companies and how they dealt with emerging risks

3. Continued

Commentary on Question:
The grading rubric was looking for a ranking of techniques, along with justification. There was no best way to rank identified in the grading rubric, any order could receive credit. Full credit was given for a ranking, justification, and explaining pros and cons of each method. Most candidates did well on this part, although few received full credit.

From best to worst:

1) Brainstorming, because collective discussions will fill in individual gaps in knowledge

   Pros – many ideas, should record all of them
   Cons – free riders in the meeting, need to get everyone in one place

2) Interviews, will have good general knowledge with the team.

   Pros – can ask clarifying questions
   Cons – time consuming, Lyon might not have the expertise we need

3) Case studies, because this is relatively new topic, and will not likely find one that covers all products.

   Pros – can suggest specific risks, shows risk in context
   Cons – might not get relevant case studies

(b) Lyon's management has decided to focus on climate change as the key emerging risk.

Describe two *key* impacts of climate change on each of Lyon's four subsidiaries.

Commentary on Question:
Most candidates were able to list and describe two impacts, however, many of those candidates applied the same key impact to several subsidiaries – for example, property damage could apply to all the subs. Partial credit was given for this approach, and most candidates did well on this part. Full credit was given for identifying separate key risks for each sub.

Simple Life:
    Mortality increases from food and water insecurity, disease, and/or social unrest.
    Investment losses from climate change exposures

3. **Continued**

        AHA Health
                Increased morbidity from air pollution, or food and water supply
                Morbidity increases from diseases
        Pryde P&C
                Property damage from wind or storms, claims and liquidity risks
                Legal risk due to insureds' failure to mitigate risk
        Helios
                Storms or floods may disrupt operations
                Climate change impacts for different geographies may introduce currency risk, given their use of the Euro

(c)   Recommend a risk mitigation strategy, other than reinsurance, for each risk identified in (b). Justify your response.

Commentary on Question:
Almost all candidates received at least partial credit for this part, but most candidates did not have a recommendation for each risk identified in part b). Full credit was given for a logical mitigation recommendation for each risk. Mitigations did not have to come directly from a syllabus reference.

        Simple Life
                Mortality increases - can be mitigated by underwriting methods that take into account geography and climate risk
                Investment losses – Adopt an ESG investment strategy
        AHA Health
                Increased morbidity from pollution, air, food, etc. – communications to policy holders about steps they can take to stay healthy
                Diseases – stress test worst-case scenarios and increase risk capital
        Pryde
                Diversify by geography to reduce concentration risk
                Put in place stricter requirements for coverage – like hurricane rated construction
        Helios
                Storms or floods – have a disaster recovery plan in place, including offsite work areas to maintain operations
                Currency risk – currency hedging may be used

(d)   Explain how you would incorporate climate change risk into each of the three sections of the ORSA report.

3. **Continued**

Commentary on Question:
While almost all candidates received some credit on this part, many candidates could not identify the three sections of an ORSA Report. Full credit was given for identifying and describing the three sections, and explaining how climate risk could be incorporated into each part. Partial credit was given for each section identified, and partial credit was given for explaining how to incorporate even if a section was not identified.

1. Insurer's Risk Management Framework

   Add to governance structure who owns climate change risk
   Create a new committee to oversee, educate the board of directors
   Create risk reporting around climate change

2. Insurer's Assessment of Risk Exposure

   Stress-test scenarios, use qualitative and quantitative assessments
   Measure interrelationship of risks
   Explain any hedging or reinsurance

3. Group Assessment of Risk Capital and Prospective Solvency Assessment

   Determine metrics, VaR for example
   Extend time horizon of model to capture future potential impacts
   Determine additional capital to hold for climate risks

(e) Identify the subsidiary most likely to be impacted by climate change. Justify your answer.

Commentary on Question:
Most candidates did well on this question. Full credit was given for identifying a sub, and having two or more logical justifications. Most candidates identified Pryde, but other subs could also get full credit with justification.

Pryde would be most likely to be impacted by climate change, given that it insures events directly tied to weather and climate events. It is concentrated in risky areas, with its largest state being CA (wildfire risk made worse by wind and drought), and then TX, GA, FL, MS, all with hurricane risk exposure. This could result in large claims impacting Pryde's ability to meet its obligations.

4. **Learning Objectives:**
1. The candidate will understand the ERM framework and process and be able to apply them to organizations.

3. The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.

5. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

6. The candidate will understand the concept of economic capital, risk measures in capital assessment and techniques to allocate the cost of risks within business units.

Learning Outcomes:
(1b) Demonstrate an understanding of the perspectives of regulators, rating agencies, stock analysts, auditors and company stakeholders and how they evaluate the risks and the risk management of an organization.

(3a) Demonstrate how each of the financial and non-financial risks faced by an organization can be amenable to quantitative analysis.

(3b) Demonstrate organization-wide risk aggregation techniques that illustrate the concept of risk diversification by incorporating the use of correlation.

(3d) Demonstrate the use of scenario analysis and stress testing in the measurement of current and emerging risks.

(5i) Choose appropriate techniques to measure, model and manage various financial and non-financial risks faced by an organization.

(6b) Apply risk measures and demonstrate how to use them in value and capital assessment

(6d) Demonstrate the ability to develop a capital model for a hypothetical organization

Sources:
ERM-101-12: Measurement and Modeling of Dependencies in Economic Capital (Ch 3-5)

ERM-106-12: Economic Capital-Practical Considerations-Milliman

ERM-119-14: Aggregation of risks and Allocation of Capital (Sections 4-7 Excluding 6.3)

4. **Continued**

ERM-131-18: Leveraging COSO Across The Three Lines Of Defenses

ERM-137-20: ORSA and the Regulator by AAA

Commentary on Question:
The goal of the question is for candidates to understand the uses of stress and scenario testing for ERM-related applications. A candidate should be able to understand the main risks a company faces and be able to explain how to model those risks. They should also be able to recommend and defend aspects of internal models.

Solution:
(a)   XYZ currently has limited capacity to implement stochastic scenario testing and plans to apply stochastic modeling for a single product at this time.

(i)   Assess, for each product, which risk type would be best suited for stochastic modeling.

(ii)   Recommend which product should be selected for stochastic modeling. Justify your response.

Commentary on Question:
Candidates did reasonably well on this part. Even though the suggested answers were market risk for UL and Fixed Deferred Annuity, the asset/credit risk answer was also accepted if the candidates provided their explanation for the answer. For part ii), both the UL and the Variable Annuity answers were accepted for full credit if there was sufficient explanation.

(a)i –

1. Traditional Life Insurance
    - Insurance risk is the most important risk impacting traditional life insurance. It would be best suited for stochastic modelling, given the large impact changes in mortality claims can affect traditional life insurance.
2. Universal Life
    - Credit/Asset risk should be modelled stochastically. For the UL products, they face significant risk due to guaranteed crediting rate. If the assets backing the UL product experience changes in interest rates or experience credit downgrades, this will drastically impact the profitability of UL policies. Modelling this stochastically will allow XYZ to better understand their sensitivity to these factors.

4. Continued

3. Fixed Deferred Annuity
    - Credit/Asset risk should be modelled stochastically. Like UL, the fixed deferred annuity has a guaranteed crediting rate and will face similar risks as UL. Understanding interest rate impacts are of key importance to this product line.
4. Variable Annuity
    - Market risk is the risk that should be modelled stochastically. Market variables have a drastic impact on VA products and are highly unknown variables. Given the potential for downside risk for policyholders, they are more likely to lapse their policies in stressed market conditions. Testing this stochastically can help assess the appropriateness of the assumptions for the product.

(a)ii –

UL should be selected for stochastic modelling. UL is highly dependent on economic variables, which are best assessed through stochastic modelling. Additionally, XYZ has the most exposure to the UL product line. It would make the most sense for XYZ to focus their efforts, especially for something as computationally intensive as stochastic modelling, on something that is likely to have a material impact to the company

(b)   XYZ is considering the following four aggregation approaches for calculating Economic Capital:

- Fixed diversification percentage
- Correlation matrix based on its own experience
- Correlation matrix based on industry experience
- Copulas. The software that XYZ has licensed can model copulas, although XYZ has done limited testing of that capability.

Recommend an aggregation technique appropriate for XYZ. Justify your response.

Commentary on Question:
Candidates did reasonably well on this part. Full credit was given for both the correlation matrix based on industry experience and copulas. Sufficient explanation of the answer was required for full credit. Candidates who chose the correlation matrix based on own experience, received partial credit. No credit was given for selecting the fixed diversification percentage answer.

4.   Continued

Recommend a Correlation Matrix based on Industry Experience.

A correlation matrix is more appropriate method to aggregate risk compared to the fixed diversification method. This method is easy to communicate and can be understood by senior management. It allows for interactions between risks. We can easily add risks, subsidiaries, or lines of business. By relying on industry experience, the resultant correlation matrix is more credible and reliable than one developed based purely on the company's limited experience data. A fixed diversification percentage would likely be too simplistic, while the use of copulas may be outside the capabilities of XYZ at this time.

(c)   At the quarterly meeting of XYZ senior managers, the topic of scenario and stress testing in the internal models was discussed. The following items were specifically mentioned by the CEO:

- Because our ERM department serves as our company's first line of defense, our CRO and her team should be responsible for developing the scenarios and stresses.
- We will rely on the ERM team to explain the results.
- Our risks are siloed enough that we should not have to worry about dependencies.
- These results should be provided shortly after quarter-end reporting if we are to use them in our planning processes.

Critique each of the CEO's statements.

Commentary on Question:
Candidates did reasonably well on this part. Most candidates received full credit for part c). The only statement some candidates struggled with was whether ERM was first or second line of defense although most candidates got this correctly.

1. ERM department serves as a second line of defense in XYZ company. The ERM department is a control function that monitors and works closely with the first line of defense.
2. ERM team in addition to the CRO are the ones who should report and explain the results of the internal model since it is within their ownership.
3. XYZ company's risks are not siloed, and the dependencies must be considered while calculating the economic capital. Some risks can be uncorrelated in the normal times, however, in the stressed times, it moves together. Noting that the EC is calculated to assess the expected amount of capital needed to cover losses in the tail events (stressed times).

4. Continued

    4. The EC calculated by the internal model should be developed in adequate time and should be rushed to be done within a short time to have proper time of validation and testing. Presenting the results shortly after quarter-end reporting will expose XYZ company to operational risk of reporting faulty EC results that might put the company solvency position at risk. ERM team should have time to make the proper validation of the data, process, models, results, aggregation

(d) In past cycles, XYZ has leveraged stress tests promulgated by regulators to demonstrate the strength of the business.

Explain why adopting an internal model could be viewed favorably by regulators.

Commentary on Question:
Candidates did reasonably well on this part. Most candidates received at least a partial credit for their answers. For this part, the grading was fairly liberal in awarding points for responses that make sense beyond the 4 listed in the rubric.

Adopting an internal model allows for better customization of the model by the company. This is favorable for regulators, given their primary goal is to ensure solvency. Improvement to modelling techniques are favored by regulators since it helps to ensure that the products are properly priced, and the reserves are better modelled.

Additionally, since the internal model XYZ is adopting will be using software from a third party, it is likely to be viewed favorably by regulators since external vendors typically update their products frequently and have the products go through vigorous testing before hitting the market

5.

Learning Objectives:

2. The candidate will understand the types of risks faced by an entity and be able to identify and analyze these risks.

4. The candidate will understand how the risks faced by an entity can be quantified and the use of metrics to measure risk.

5. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

Learning Outcomes:

(2c) Identify and analyze specific risks faced by an organization, including but not limited to: financial, environmental, operational, legal, reputational and strategic risks.

(4c) Analyze risks that are not easily quantifiable, such as liquidity, operational, and environmental risks.

(5i) Choose appropriate techniques to measure, model and manage various financial and non-financial risks faced by an organization.

Sources:

Value-at- Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion Ch. 13 Liquidity Risk

ERM-136-20: Managing Liquidity Risk: Industry practices and recommendations for CROs

ERM-145-21: IAA Paper: Importance of Climate-Related Risks for Actuaries

Commentary on Question:

The question intended to identify candidates who understand the two types of liquidity risk, how each of the two types would arise from the operations of the company described, and actions that the company was taking or could take to manage the risk.

Many candidates answered the question parts in a somewhat unstructured way, for example providing recommendations on how to improve risk management as part of their discussion of current risk management, i.e. answering b-ii within their answers to parts a-ii or b-i. Marks were given regardless of the geography of the answer within the question parts.

More candidates understood the asset-related liquidity risk than the liability-related risk. Almost one third of candidates did not correctly describe cash-flow or funding liquidity risk.

5. **Continued**

Most candidates correctly referenced the challenge of cash flow volatility resulting from wild fire claims and COVID claims. Most also correctly noted the absence of and potential benefit of reinsurance in the property and health subsidiaries. Most correctly noted that the informal support from QRY to Homeguard should be formalized, and would only help if QRY had sufficient liquidity. Many noted the benefit of the ALM process, and properly suggested that it could be strengthened.

Some common errors or omissions:
- *Incorrectly describing US Treasuries as illiquid investments.*
- *Omitting to note that the potential new acquisition would be expected to reduce current liquidity*
- *Most candidates neglected to mention elements of governance which would strengthen liquidity risk management, such as a liquidity contingency plan, risk appetite statement/limits or economic capital modelling.*

Solution:
(a)

> (i) Describe the two types of liquidity risk.

> (ii) Evaluate how the current operations and planned activities expose QRY to each type of liquidity risk.

> Solution:
> (i) Asset liquidity risk: inability to sell assets at their market price, due to impact from bid-ask spread or impact from price-market depth.
>
> Funding liquidity risk: inability to fulfill liability obligations, often due to mismatch in timing of asset and liability cash flows.

> (ii) All companies have potential timing mismatch between claim payments and asset cash flows. The concentration of policies in California for California HomeGuard without there being any reinsurance leaves QRY open to funding liquidity risk, as they may face larger than expect claims and not have the funds readily available to pay them.
>
> Hollywood Life faces asset risk since it has added private placements and oil and gas investments to increase yield. These assets may not be as liquid and may have more price volatility that could result in them having to sell for a lower return than expected. This is especially true of oil and gas in light of transition risk due to climate change.
>
> Investing in a new subsidiary can also result in liquidity risk since it will likely require an upfront investment of funds.

5. Continued

Weaker profitability may be draining capital from the holding company, which doesn't have any liquidity management.

(b)
(i) Evaluate existing risk management techniques for liquidity risk for QRY and its subsidiaries based on the information provided above.

(ii) Recommend improvements to liquidity risk management for QRY and its subsidiaries, including both changes to existing risk management techniques and new approaches. Justify your response.

Solution:

(i) Hollywood Life: use of quota share reinsurance helps manage cash flow volatility, but 20% is too low and quota share doesn't limit tail risk. ALM is in place to manage the interest rate volatility and may help align cash flow timing.

California HomeGuard informally relies on holding company as catastrophe reinsurance. This may help the subsidiary but not overall QRY liquidity risk.

(ii) Hollywood Life: adjust investment mix to investments that are not at such high risk of losing value in the short and long term.

All subsidiaries: enter reinsurance contracts

Increase frequency of A/L rebalancing/checking

California HomeGuard: explore spreading out business geographically in order to diversify.

Begin monitoring liquidity position on a periodic basis (frequent enough to catch issues)

6. **Learning Objectives:**
1. The candidate will understand the ERM framework and process and be able to apply them to organizations.

4. The candidate will understand how the risks faced by an entity can be quantified and the use of metrics to measure risk.

5. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

Learning Outcomes:
(1d) Assess the overall risk exposure arising from an organization's current and emerging risks.

(1e) Propose ERM solutions or strategies that effectively manage risk under different real (case study) and hypothetical situations facing financial and non-financial organizations.

(4a) Determine risk exposures using common risk measures (e.g., VaR and TVaR) and compare the properties and limitations of such measures.

(4b) Analyze quantitative financial and non-financial data using appropriate statistical methods to assist in quantifying risk.

(5b) Demonstrate application of the following responses to risk, including consideration of their costs and benefits: avoidance, acceptance, reduction without transfer, and transfer to a third party.

(5e) Determine an appropriate choice of mitigation strategy for a given situation, which balances benefits with inherent costs (including exposure to moral hazard, credit, basis and other risks).

Sources:
ERM-119-14: Aggregation of risks and Allocation of Capital (Sections 4-7 Excluding 6.3)

6. **Continued**

ERM-135-20: Risk Management and the Rating Process for Insurance Companies by A.M. Best

ERM-139-20: Quantitative Enterprise Risk Management by Mary Hardy, Chapter 7: Copulas

Financial Enterprise Risk Management, Sweeting, 2017 Ch. 16 Responses to Risk

Value-at- Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion Ch. 12 Monte Carlo Methods

Risk Appetite: Linkage with Strategic Planning Report

Commentary on Question:
Candidates generally performed well on this question. Many candidates were able to perform the required calculations correctly and use the results to inform their responses for subsequent parts of the question. The best quality responses drew from specific details outlined in the question stem; more general responses were awarded points, but typically not full credit.

Solution:
(a)   A normal distribution is used to estimate the annual claim loss for each line of business below. The risk tolerance is set to the maximum annual claim loss for each line that management is willing to accept. ABC management defines the aggregate risk tolerance for the company as the sum of risk tolerances for each line of business.

Annual Claim Losses

Line of Business	Mean ($ million)	Standard Deviation ($ million)	Risk Tolerance ($ million)
Auto	200	20	210
Property	40	5	45

(i)   Calculate the probability that annual claim losses are above the risk tolerance for each line of business. Show your work.

(ii)   Calculate the probability that at least one of the lines of business losses is above the risk tolerance using the Clayton Copula function for the dependence below using the tab 'Q6(a)(i)(ii)' in the accompanying Excel workbook. Show your work.

$C(u_1, u_2) = (u_1^{-2} + u_2^{-2} - 1)^{-1/2}$

6. Continued

      (iii)   Recommend two risk management actions to lower the aggregate risk of the portfolio. Justify your response.

Commentary on Question:
Many candidates performed well on the calculations for part (a)i; however, many candidates did not use the appropriate inputs from (a)i in the calculation for part (a)ii.

Most candidates were able to describe appropriate risk management actions to lower aggregate risk; however, responses related to modifying aggregation calculations/diversification did not receive credit since they do not address the underlying risk of the block of business.

(a)i – see [Q6 (a)i-ii] tab for solution

(a)ii – see [Q6 (a)i-ii] tab for solution

(a)iii –

ABC can reduce the aggregate risk of its portfolio by ceding a portion of the business to a reinsurance company. By purchasing Excess of Loss reinsurance, ABC can limit total losses for one or both lines of business.

ABC can also reduce aggregate risk by modifying its product design to include risk sharing components. By introducing, say, a deductible to its auto policy, policyholders would share some of the risk with ABC and would potentially eliminate smaller claims from being submitted to ABC.

(b)   A stochastic model was used to create 10,000 simulations of ABC's annual losses by line of business. The table in the accompanying Excel workbook, tab 'Q6(b)(i)(ii)(iii)', shows the 100 highest total simulated losses (in $ millions). The company uses Risk-Adjusted Return on Risk-Adjusted Capital (RARORAC) and Economic Value Added (EVA) in analyzing its results.

    Assume the following:

- The total required risk capital for ABC is $200 million and the opportunity cost is 8%.
- The projected risk-adjusted return is $5 million for Auto and $4 million for Property.
- The projected net income is equal to projected risk-adjusted return for each line of business.

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6. Continued

    (i)   Calculate the amount of risk capital to assign to each line of business using a Co-TVaR capital allocation approach at the 99.6 percentile. Show your work.

    (ii)   Calculate RARORAC for each line of business. Show your work.

    (iii)   Calculate EVA for each line of business. Show your work.

    (iv)   Recommend two risk mitigation actions for the company given the RARORAC and EVA for each line of business. Justify your response.

Commentary on Question:
Many candidates performed well on the calculation components of (b). There were common themes for candidates who did not receive full credit for (b)i-iii:
    1) they reordered the scenarios when calculating the product line Co-TVaRs,
    2) they did not allocate the $200M required risk capital to the individual product lines (instead using just the Co-TVaR as the allocated capital), or
    3) were unable to correctly calculate RARORAC or EVA.

Although RARORAC was not defined on the syllabus, it was defined in the stem of the question ("The company uses Risk-Adjusted Return on Risk-Adjusted Capital"). Candidates were provided the risk-adjusted return amounts later in the stem and were asked to calculate the risk-adjusted capital amounts in Part (b)(i) so the information to calculate this metric was contained within the question. Candidates who were able to develop the correct RARORAC values for the two lines of business used the information as described above.

(b)i – see [Q6 (b)i-iii] tab for solution

(b)ii – see [Q6 (b)i-iii] tab for solution

(b)iii – see [Q6 (b)i-iii] tab for solution

(b)iv –

The RARORAC for auto falls below the cost of capital, and the EVA is negative – therefore ABC should consider exiting the auto line to free up capital for more profitable ventures – like the property business or expansion into new markets.

6. Continued

Alternatively, since the RARORAC and EVA for the auto line of business is lower than comparable metrics for the property line, and a higher amount of capital is required to support auto, a reinsurance program could be implemented. This will lower the amount of risk for the block of business by potentially eliminating or reducing large auto claims.

(c) ABC executives target a 20% growth in auto insurance sales.

A new bonus structure is being introduced to incentivize sales growth over a one-year horizon. You discover that the executive bonus structure is heavily tied to sales growth but does not consider risk.

(i) Explain what risk governance issues are created by this bonus structure.

(ii) Recommend two additions to the executive bonus structure to mitigate the risk governance issues you identified in (i). Justify your response.

Commentary on Question:
Nearly all candidates were able to identify the key risk governance issue with the new bonus structure, but full points were only given to candidates that discussed multiple issues as the question directed.

Most candidates performed well on (c)ii. Candidates not receiving full credit on (c)ii typically made suggestions on changes beyond the bonus structure itself.

(c)i –
The executive bonus plan rewards the executives to take on more risk without consideration of risk tolerances or adequate returns for the risks taken. By prioritizing sales at all costs, the risk profile of the auto line is likely to change in an adverse manner, potentially increasing future claim costs and further straining the viability of the auto line of business.

Additionally, a one-year time horizon is quite short and ignores risks that may arise further in the future. Profitability for each product line is heavily dependent on products remaining in force as large first year expenses need to be recouped through renewal premiums. Agents could boost short term growth sales by submitting policies and deliberately cancelling them after it they contribute to the calculation of the growth metric.

6. **Continued**

(c)ii –

The metrics determining bonus payout/eligibility should not solely be based on sales. Recommend basing it on profitability metrics, such as value of new business projections at issue, which will account for both risk and return.

The bonus structure should be changed to pay out after 3 years. This will diminish the incentive to put adverse risk on the books to boost sales figures followed by mass churn. This will motivate the executives to sell policies aligned with the desired risk profile of the company.

7. **Learning Objectives:**
4.   The candidate will understand how the risks faced by an entity can be quantified
        and the use of metrics to measure risk.

Learning Outcomes:
(4a)   Determine risk exposures using common risk measures (e.g., VaR and TVaR) and
        compare the properties and limitations of such measures.

(4b)   Analyze quantitative financial and non-financial data using appropriate statistical
        methods to assist in quantifying risk.

Sources:
Value at Risk, Jorion, Chapter 11, VAR Mapping

Value at Risk, Jorion, Chapter 17, VAR and Risk Budgeting in Investment Management
(excluding 17.3 and 17.4)

Commentary on Question:
*The goal of this question is to test a candidate's understanding of Value-at-Risk (VaR)
and risk budgeting. Most candidates were able to score some marks in calculating
discounted cash flows and showing their work to arrive at the final portfolio VaR on part
(a). For part (b), partial marks were awarded to candidates when risk budget equation
was properly set up, even though few solved for the correct allocations. Many candidates
received full or partial credits with reasonable justifications on part (c).*

Solution:
(a)   Calculate the diversified 1 year horizon VaR (95%) of the bond portfolio using
        the cash flow mapping approach. Show your work.

        Commentary on Question:
        *Most candidates were able to score some marks in calculating discounted cash
        flows and showing their work to arrive at the final portfolio VaR.*

        Part (a) in Excel spreadsheet.

(b)   Calculate the value to be reallocated between the equity and corporate bond
        portfolios to achieve a total risk budget of $2 million. Show your work.

7. **Continued**

Part (b) in Excel spreadsheet.

(c)   Evaluate the Chief Actuary's recommendation.

We recommend staying with the budget by allocating $5.1M in equity to strike the balance between risk and return. Getting higher investment return by allocating more to equity will likely lead higher profitability along with higher risk. However, by allocating $6M in equity, the risk budget limit is breached. This can lead to higher VaR or introduce more volatilities or capital requirement that GSI may not be able to afford or manage. VaR provides forward-looking measure of risk, using combination of current positions with risk forecasts. VaR also allows improved control of portfolio risk and of managers. It cuts through the maze of diversification rules, benchmark portfolios and investment guidelines.

8.

Learning Objectives:

4. The candidate will understand how the risks faced by an entity can be quantified and the use of metrics to measure risk.

5. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

Learning Outcomes:

(4a) Determine risk exposures using common risk measures (e.g., VaR and TVaR) and compare the properties and limitations of such measures.

(5d) Demonstrate how derivatives, synthetic securities, and financial contracting may be used to reduce risk within a static or dynamic hedging program.

(5e) Determine an appropriate choice of mitigation strategy for a given situation, which balances benefits with inherent costs (including exposure to moral hazard, credit, basis and other risks).

(5g) Analyze how ALM and other risk management principles can be used to establish investment policy and strategy, including asset allocation.

Sources:

ERM-620-21: The Evolution of LDI and Role of a Completion Manager

ERM-621-21: Liability Driven Investment Explained

ERM-617-19: Chapter 29 (pp 670-686) of Options, Futures, and Other Derivatives

Commentary on Question:

This question tests candidates' understanding of liability-driven investments and embedded bond options. Most candidates did well on parts (b) and (c), and most candidates did not perform well on parts (d) and (f). Full marks for (a)-(e) were awarded to candidates who understood how to hedge the pension plan's interest rate risk using zero coupon bonds and interest rate swaps. For part (f), many candidates confused the structure and calculations for bond options with equity options.

Solution:

(a) Describe two factors that the plan must consider from a completion portfolio perspective when using hedging assets.

Commentary on Question:
Most candidates struggled on this part. To receive full credit, candidates needed to describe two distinct hedging considerations which link the assets and the liabilities. Many candidates lost marks because they didn't mention the liabilities in their responses.

8. Continued

Duration: The duration of the assets should be aligned with the duration of the liabilities.

Credit exposure: The credit exposure of the completion portfolio should be compared to the liability benchmark.

(b)   Compare and contrast using zero coupon bonds vs. using zero coupon interest rate swaps to match the plan's liabilities.

Commentary on Question:
This question tested candidates understanding of the features and shortfalls of using both instruments for hedging. Both similarities and differences were required to obtain full marks for this question. Candidates who lost marks typically did not mention cash flow differences or provided high level descriptions of zero coupon bonds and swaps.

Both zero coupon bonds and swaps can be used to manage interest rate sensitivities.

Zero coupon bonds are able to match the plan's liabilities because a change in interest rates affects the value of the bond and the value of the liabilities similarly. They are effective, but require cash to purchase up front, which reduces the plan's ability to invest in other growth assets.

Zero coupon interest rate swaps are also effective at matching liability duration, as their values also vary with interest rates. Unlike bonds, swaps do not require an upfront purchase, allowing the plan to invest capital in other assets. Swaps are more complex than bonds due to uncertainty of cash flows, but are also more flexible in their ability to manage duration.

(c)   Describe the cash flows at time zero and at the end of five years:

(i)   Using zero coupon bonds

(ii)   Using zero coupon interest rate swaps

Commentary on Question:
Candidates generally performed well on this part. Candidates who received full marks demonstrated the connection between the cost of the bond and maturity value, and showed how to calculate the swaps' settlement value.

8. **Continued**

       (i)   Time zero: Cash outflow = $1.5M / ((1.05) ^ 5) = $1.175 to purchase the bond.
              Time 5: The bond pays out a maturity value equal to its notional amount, $1.5M.

       (ii)   Time zero: There is no initial cash outflow. The plan locks in an interest rate of 5% at inception.
              Time 5: There is a final exchange, equal to the difference between the accrued floating interest over the life of the swap and 5%, times the notional value. If interest rates rise, the pension plan pays the difference. If interest rates fall, the pension plan receives this difference.

(d)   Demonstrate that both methods protect against risk if the risk-free rate falls by 1% immediately. Show your work.

    Commentary on Question:
    Candidates generally struggled on this part. The question was looking for candidates to show that the value of interest rate swaps, zero coupon bonds, and the pension plan's liabilities changed by an equivalent amount. Many candidates struggled to solve for the change in interest rate swap value. Some candidates compared the change in bond value to the change in swap value, but did not relate this change to the liabilities. These candidates received no greater than half marks for this part.

    Solution for part (d) is included in the spreadsheet

(e)   Recommend which method to use. Justify your recommendation.

    Commentary on Question:
    There are several acceptable responses for this question. It was possible, albeit more difficult, to recommend bonds and receive full marks. Candidates who received full marks typically connected at least one pro or con from part (b) to their recommendation.

    I recommend using the interest rate swap to protect against interest rate risk. Unlike with a bond, interest rate swaps require zero cash outflow at inception to enter. By not purchasing a bond, the pension plan has more cash to invest in growth assets to support their liabilities.

8. Continued

(f)   Max is considering using a callable bond with an embedded call option from the issuer to support the pension plan.

- The bond has a current market value of $1.1 million.
- The embedded call option matures in one year and has a strike of $1.5 million.
- The volatility of the call option is assumed to be 10%.

(i)   Calculate the value of the option. Show your work.

(ii)   Describe the benefits and risks of using a callable bond with embedded call option to support the pension plan.

Commentary on Question:
Most candidates struggled with this part. In part (i), almost every candidate used the bond's market value for the option price, rather than the present value of the embedded call option. Part marks were awarded for candidates who used the correct formula, even if the final answer was incorrect. For part (ii), many candidates treated the option similar to an equity option. Unlike with stock options, bond options are held by the borrower (bond issuer), not the lender (pension plan). These responses did not receive credit.

(i)   Solution included in Excel spreadsheet.

(ii)   Benefit: Callable bonds typically offer a higher yield than non-callable bonds, and therefore are less expensive to purchase.

Risk: Callable bonds offer the issuer the option to redeem the bond. If interest rates drop, it is in the issuer's interest to redeem the bond and issue a lower yielding tenor. This leaves the pension plan with reinvestment risk, arising from the need to replace the bond's return in a lower interest rate environment.